IV-02.01 General Policies and Procedures

IV-02.01.1 Alternate Designs

The use of alternate designs is encouraged by the FHWA. This subject should be discussed at the pre-design meeting and a decision made whether or not alternate designs will be prepared. The decision should be based on whether there is an obvious low cost alternative, and then whether there is adequate design time and sufficient staffing to prepare alternate plans.

IV-02.01.2 Design Live Load

The design live load, whether H, HS, Railroad, or Military, should be shown on the structural layout plan sheet.

IV-02.01.3 Elevations

Bridge elevations should be shown on the structural layout sheet. The elevation of the roadway centerline should be specified at begin bridge, end bridge, and over piers. The elevation of the bottom of all footings should also be shown, as well as at other locations on the structure that the designer determines appropriate.

IV-02.01.4 Temporary Bypasses

Temporary bypasses for structural projects should be designed in accordance with the requirements of Section 710, North Dakota Standard Specifications for Road and Bridge Construction.

IV-02.01.5 Bridge Quantities

Bridge quantities should be given to the nearest whole number, with the exception of concrete, which should be shown to the nearest tenth of a cubic yard. The unit of payment for the various structural items should be as stated in the North Dakota Standard Specifications for Road and Bridge Construction. Generally, Class 1 and Class 2 excavation should be paid for by lump sum quantity, and the estimated quantity in cubic yards should be shown on the plans. On projects where the excavation quantities are larger than normal, Class 1 and Class 2 excavation should be paid for by cubic yards. Channel excavation should be paid for by the cubic yard, but a plan note should indicate that payment will be made for plan quantity only.

IV-02.01.6 Structural Code Number

The structural code number, as shown below, should be put on the upper right corner of the structural layout sheet:

FIRST DIGIT: X - - -	"X"	Bridges (structures over 20 feet long). The first digit (code"X") indicates the bridge classification

2ND DIGIT: The second digit indicates the main function of the structure:

X0 - -	Highway over waterway
X1 - -	Highway over railroad
X2 - -	Highway over highway
X3 - -	Highway over waterway and railroad
X4 - -	Highway over waterway and highway
X5 - -	Highway over railroad and highway
X6 - -	Highway under railroad
X7 - -	Highway under highway
X8 - -	Highway under railroad and highway
X9 - -	Other combinations, including highway over waterway, railroad, and highway; also 3- and 4-level grade separations and miscellaneous.

Note: In determining whether to code X2 - - (Highway over highway), or X7 - - (Highway under highway), use the highway hierarchy system with the higher class highway going first. For example, in Bismarck where I-94 crosses over Washington Street, it would be coded X2 - -; where I-94 goes under State Street (US-83), it would be coded X7 - -.

3RD DIGIT: The third digit identifies the material of the principal supporting span members of the span identified by the fourth digit:

X - 0 -	Timber
X - 1 -	Masonry
X - 2 -	Concrete, not prestressed
X - 3 -	Steel
X - 4 -	Steel and concrete
X - 5 -	Timber and steel
X - 6 -	Timber and concrete
X - 7 -	Composite steel and concrete
X - 8 -	Concrete, prestressed
X - 9 -	Aluminum

4TH DIGIT:	The fourth digit identifies the type of span (identifies main span type if the bridge has two or more span types):
X - - 0	Slab
X - - 1	Girder
X - - 2	Truss (except cantilever)
X - - 3	Rigid beams
X - - 4	Arch
X - - 5	Cantilever truss
X - - 6	Moveable
X - - 7	Suspension
X - - 8	Box culvert (bridge length)
X909	Highway tunnels
Y009	Pedestrian overpasses or underpasses

IV-02.01.7 Structural Plan Sheet Sequence

The general sequence of the structural plan sheets is as follows (this is a guide only):

Layout Sheet
Quantity Sheet
Notes
Boring Logs
Pile Layout and Miscellaneous (Hydraulics)
Abutments
Piers
Girders
Slab
Reinforcing Steel
Approach Slab
Standard Drawings

IV-02.02 Geometrics

IV-02.02.1 Bridge Widths

The minimum clear roadway width should be as specified in Table VI-5 and Table VI-6 of AASHTO's "A Policy on Geometric Design of Highways and Streets", except that the minimum for mainline Interstate and railroad overheads should be 40'. The 40' on Interstate mainline is based on two - 12' lanes, a 10' right shoulder, and a 6' left shoulder. Certain urban roads may require different shoulder widths.

IV-02.02.2 Grade Recommendations

For drainage purposes, the minimum longitudinal grade should be 0.2 percent. A maximum longitudinal grade of 3 percent is recommended. All bridges should have a minimum cross slope (transverse grade) of 0.1 percent, but normally should be 1/4" per foot. Other geometric requirements may supersede these recommendations.

IV-02.02.3 Clearances

It is recommended that vertical clearances on grade separations be 16'-6", but in no case should be less than 14' 6". Horizontal clearance should be 30'-0" from the edge of the driving lane. Exceptions should meet requirements of the AASHTO roadside design guide.

IV-02.02.4 Foreslopes

Foreslopes should be 4:1 for Interstate over minor roads and railroads, and 3:1 for all others.

IV-02.02.5 Horizontal Curves

In working with the geometry of horizontal curves, the arc definition should be used.

IV-02.02.6 Navigational Clearance

When designing a structure where navigational clearance is an issue, the policies and procedures in the Code Of Federal Regulations, 23CFR650H, should be followed.

IV-02.02.7 Pedestrian Facilities

When designing pedestrian facilities for a structural project, the facilities should be designed per AASHTO requirements.

IV-02.03 Foundations

IV-02.03.1 Footing Elevations

Footing elevations should be shown on the boring logs.

IV-02.03.2 Bearing Piles

Plans should show the required pile bearing capacity for each substructure unit. The required pile bearing shown should be the maximum allowed by AASHTO specifications for that size pile unless the engineer determines that a special case exists and a lesser capacity is selected. Minimum pile penetration should be shown on the plans if the design engineer, in consultation with the geotechnical engineer, determine that underlying soil layers may present a situation that may lead to a pile failure

IV-02.03.3 Piling Layout

The plans should have a piling layout, separate from the structural layout sheet. When test piles are specified, their location should be designated on the piling layout.

IV-02.03.4 Pile Types

The type of pile to be used is generally specified in the soils report. On structure widening projects, the use of the same type of piling as was used in the existing structure is recommended.

IV-02.03.5 Design of Friction Piling

Friction piling should be designed in accordance with the instructions in Appendix IV-04D.

IV-02.03.6 Test Piles

A test pile generally is not required.

IV-02.03.7 Pile Load Tests

Should be required when using allowable pile stress that is greater than the AASHTO design stress.

IV-02.04 Abutments

IV-02.04.1 Integral Abutments

Integral Abutments are preferred when the geometrics allow for a jointless bridge deck. Following are design constraints for integral type abutments:

Maximum height	12'-0"
Minimum thickness	2'-0"
Minimum embedment in embankment	3'-0" (incl depth of riprap)
Maximum embedment in embankment	5'-0" (incl depth of riprap)

For design example, see Appendix IV-04F.

IV-02.04.2 Non-integral Abutments

Use of non-integral type abutments should be as dictated by design and geometric requirements.

IV-02.04.3 Pile Spacing

The approximate maximum spacing for steel piles in an integral type abutment should be 10'-0". The approximate maximum spacing for timber piles in an integral abutment should be 7'-0". The minimum spacing for all piles should be 2'-6".

IV-02.04.4 Pile Embedment

Piles should be embedded a minimum of three feet into the wall of integral type abutments. Maximum embedment should be governed by punching shear.

IV-02.04.5 Pile Orientation

Steel "H" piles in integral type abutments should be oriented so that the strong axis is perpendicular to the face of the abutment.

IV-02.04.6 Allowable Pile Loadings

The maximum allowable pile loads for various types of pile are as follows:

<u>Steel H-pile:</u>

Commonly used sizes:	HP10x42 - - - - 55 tons
	HP12x53 - - - - 70 tons
	HP14x73 - - - - 97 tons

These allowables are based on $0.25F_y$ (9000 psi) and can be increased to $0.33F_y$ if the additional requirements of AASHTO are met. Base allowable loads for other sizes on $0.25F_y$.

Timber Piles:

Butt Diameter	Capacity
10"	20 tons
12"	24 tons
14"	28 tons
16"	32 tons

These capacities are based on the table on page 45 of the Eleventh Edition (1973) of the AASHTO Standard Specifications for Highway Bridges.

<u>Steel Encased Concrete (SEC) Piles:</u>

AASHTO loads for SEC piling are based on $0.25F_y A_s + 0.40f_c'A_c$ where F_y = 35,000 psi and f_c' = 3000 psi. The area of steel (A_s) is computed assuming 1/16" of steel is corroded off of the outside diameter of the pipe. When driving the steel shell of SEC pile, care should be taken not to exceed the allowable driving stress on the steel.

The allowable driving stresses on pile should be according to the AASHTO specifications.

Sometimes the soil conditions cannot support the maximum pile loads. The designer should consult with the geotechnical engineer to determine the allowable pile loads

IV-02.04.7 Pile Design for Scour

The estimated depth of scour and volume of soil removed along the length of pile should be considered in pile design. Refer to the design procedures section of Chapter 3 found in HEC-18 for further guidance.

IV-02.04.8 Spread Footings

Use spread footings only when piling cannot be feasibly driven. AASHTO design procedures and safety factors should be used for the design of spread footings.

IV-02.04.9 Wings for Integral Abutments

Slope of wings should range from 4:1 to 2:1. Wing lengths should range from a minimum of 6'-0" to a maximum of 12'-0". Wings for integral abutments should have flat bottoms. A 0E wing angle is preferred, but may be angled up to 90E if there are no piling in the wing.

IV-02.04.10 Class of Concrete, and Type of Cement

Class AE-3 concrete should be used in abutments. Unless specified in the plans, the type of cement used in abutment concrete should be as stated in the North Dakota Standard Specifications for Road and Bridge Construction, which is Type I or IA. The need for sulfate resistant cement should be determined in the hydraulic report, or at the TS&L inspection, and if required should be noted on the plans.

IV-02.04.11 Abutment Concrete Finish

Surfaces should receive the rubbed finish (surface finish “C”) unless otherwise called for on the plans. For areas that are highly visible to the public, consideration should be given to the use of surface finish “D”. Graffiti protection should also be considered in these locations.

IV-02.04.12 Bridge Length Using Integral Abutments

The maximum length of bridge, with integral abutments and no expansion joints, should be 400' with a 0Eskew. For bridges that are skewed, the maximum bridge length with integral abutments and no expansion joints should be 400' multiplied by the cosine of the skew angle. Using integral abutments, the maximum bridge skew angle is 30E.

IV-02.04.13 Backfill, Drainage, and Waterproofing

Seepage trenches are generally used behind all abutments. See sketch, Appendix IV-04C. If seepage trenches are not provided, seepage holes should be provided through the walls. These holes should be located close to the bottom of the backfill material. Vertical drainage and/or perforated pipe may be used as site conditions warrant. Two-ply fabric waterproofing should be used at all construction joints.

IV-02.04.14 Earth Pressure on Abutment Walls

Use 1,000 pounds per square foot on integral abutment walls, 650 psf on integral wing walls. For integral abutments, use B_E = 1.0 for walls and wings. Use 40 psf on other walls, or a value calculated by Rankine or Coulomb theory of lateral earth pressure.

IV-02.04.15 Joint Between Approach Slab and Abutment

The approach slab is normally tied to the abutment or end wall. No tining of the concrete within 6" of the joint.

IV-02.04.16 Grade of Reinforcement

Grade 60 reinforcement should be used in all abutments.

IV-02.04.17 Concrete Cover Over Reinforcement

Concrete cover over reinforcing steel should be according to AASHTO. An exception to this is that concrete cover over reinforcement should be 4" where the concrete is cast against and is permanently exposed to earth.

IV-02.04.18 Minimum Reinforcement

For integral abutments, use a minimum reinforcement of No. 5 bars at 12" spacing (both directions), or that required by analysis, whichever is greater. For other abutment types, use that required by analysis of the AASHTO minimum, or the CALTRANS formula below, whichever is greater.

$P_{min} = 1.7(h/d)^2(f_c')^{1/2}/f_y$ where P = minimum reinforcement ratio
h = total depth of section
d = effective depth of section
f_c' = concrete compressive strength
f_y = yield strength of reinforcing steel

IV-02.04.19 Scour Design

Countermeasures such as riprap, guide banks (spur dikes), or other features should be used to control potential scour. These items should be discussed in the hydraulic report or TS&L comments. AASHTO 4.4.5.2 may also apply.

IV-02.04.20 Design Loads

Design according to AASHTO, using HS25 (HS25 is 25% greater than HS20). Also, use military loading if it controls on mainline Interstate bridges. One half of the first section of approach slab should be included in the dead load. For prestressed girder bridges, the load from the deck to the substructure should be designed assuming the spans are simple. If the foundation report indicates significant settlement, negative skin friction should be addressed.

IV-02.05 Piers

IV-02.05.1 Type

For stream crossings, wall type piers should generally be used. For other structures, the piers should be the designer’s preference considering economics, geometrics, and aesthetics.

IV-02.05.2 Minimum Wall Thickness

Wall type piers should have a minimum wall thickness of 20".

IV-02.05.3 Caps

Cap widths should be determined by bearing requirements, but should be no less than 24" in width for double bearing girders and 20" for single bearing. For fixed piers using prestressed girders with protruding steel, the beam end should be a minimum of 6" from the edge of the pier cap and there should be a minimum of 12" between beam ends. Integral piers should have a shear key on top of the cap. Vertical steel dowel bars are not necessary.

IV-02.05.4 Columns

Columns should be designed according to AASHTO. Columns can be either round or rectangular. They should be proportioned to the rest of the structure to present an aesthetically pleasing bridge. Minimum column dimension should be 24". Consideration should be given to standard forms when determining the size of circular columns.

IV-02.05.5 Height

The maximum height of piers without footings should be 25' to 30'. The maximum height of piers with footings is the designer's decision.

IV-02.05.6 Cofferdams

The contractor should be responsible for the design of any cofferdams used on the project.

IV-02.05.7 Pile Embedment

Design according to AASHTO, Section 4.5.15. For wall piers with a single row of piling, pile embedment should be at least height of wall/ 3, but not less than 4'-0".

IV-02.05.8 Reinforcing Steel Splices

Design splices of reinforcement according to AASHTO. Generally, lap splices are used, but mechanical and thermal splices can be used where practical and economical.

IV-02.05.9 Scour

The elevation of the pier footing, pile cap, etc., should be based on the calculated scour depth as shown in the hydraulic report and discussed in Hydraulic Engineering Circular 18.

IV-02.05.10 Grade of Reinforcement

Pier reinforcement should be Grade 60.

IV-02.05.11 Allowable Pile Loads

See IV-02.04.6.

IV-02.05.12 Pile Design for Scour

The estimated depth of scour and volume of soil removed along the length of pile should be considered in pile design. Refer to the design procedures section of Chapter 3, HEC-18 for further discussion.

IV-02.05.13 Minimum Pier Embedment

The minimum pier embedment values below are based on frost heave considerations.

For spread footings on stream crossings	Min. = 5'-0"
For spread footings, other than stream crossings:	
West and central North Dakota	Min. = 5'-0"
Eastern North Dakota	Min. = 6'-0"
Northeastern North Dakota	Min. = 7'-0"
For pile footings on stream crossings	Min. = 5'-0"
For pile footings on other than stream crossings	Min. = 4'-0"
For piers without footings	Min. = 3'-0"

Note: Footing elevations based on calculated scour depths may govern.

IV-02.05.14 Spread Footings

Spread footings should be used only when piling cannot be feasibly driven. For design of spread footings, AASHTO design methods should be used. In the design, the safety factor for sliding should be 1.5, and the safety factor for overturning should be 2.0, or as allowed by the AASHTO specifications.

IV-02.05.15 Bumper Blocks

Piers for railroad overhead structures should have protective bumper blocks. Design bumper blocks using AREA specifications.

IV-02.05.16 Ice Pressure

Stream crossing piers should be designed for ice pressure using AASHTO specifications, assuming 4'-0" ice thickness on the Missouri River and 3'-0" ice thickness on other streams.

IV-02.05.17 Class of Concrete and Type of Cement

Class AE-3 concrete should be used for piers. The type of cement should be Type I or IA, unless noted otherwise on the plans. The need for sulfate resistant cement should be covered in the hydraulics report or at the TS&L inspection, and if required should be noted on the plans.

IV-02.05.18 Concrete Surface Finish

Surfaces should receive the rubbed finish (surface finish “C”) unless otherwise noted on the plans. For areas that are highly visible to the public, consideration should be given to the use of surface finish “D”. Graffiti protection material should also be considered in these locations.

IV-02-05.19 Reinforcing Steel

For wall piers on a single row of piling, a minimum reinforcement of No. 5 bars at 12" spacing in both directions should be used.

IV-02.05.20 Concrete Cover Over Reinforcement

Concrete cover over reinforcing steel should be according to AASHTO, except that concrete cover should be 4" where concrete is cast against and is permanently exposed to earth.

IV-02.05.21 Pier Edge Treatment

Wall type piers should have 1 1/2" bevels on vertical edges. All other edges should have the 3/4" bevel required in the North Dakota Standard Specifications. All wall piers on stream crossing structures should have ice nose protection on the upstream end.

IV-02.05.22 Design Loads

Piers should be designed for AASHTO HS25 live load. Also use military load, if it controls on mainline Interstate bridges. For prestressed girder bridges, the load from the deck to the substructure should be designed assuming the spans are continuous.

IV-02.05.23 Pile Spacing

Minimum distance between the outside rows of piling should be height of pier/7, but not less than 3'-0", as required by FHWA policy.

IV-02.06 Superstructures

IV-02.06.1 Design Parameters

Continuous composite (negative and positive) design should be used on multi-span steel and prestressed concrete bridge. Continuous design should be used on slab and T-beam bridges. Slabs on prestressed concrete bridges should be considered continuous and composite for live load. Prestressed beams up to 48" in depth should be designed as continuous, composite using 90% of simple moment due to live load. Deeper beams should be designed simple composite, but detailed as continuous.

IV-02.06.2 Maximum Girder Dimensions

The maximum length and height of girders are controlled by transportation requirements. Railroad limits for hauling are approximately 165 feet for length and 15 feet for girder depth.

Truck limits are approximately 120 feet in length. Shipments with a width of 14 feet require a pilot car.

IV-02.06.3 Roadway Crown

Bridge roadway surfaces should have a transverse crown of 1/4 inch per foot.

IV-02.06.4 Bridge Skew Angle

It is preferred that the bridge skew angle not exceed 45E.

IV-02.06.5 Economical Span Arrangements

For prestressed concrete girders, use spans utilizing the same girder size when practical. For steel girders, use approximate span ratio of 1:1.3:1 and 1:1.25:1.25:1 when practical. Haunches are more costly to fabricate, so the economics should be considered when designing haunched girders.

IV-02.06.6 Maximum Live Load Deflections

According to AASHTO policy, live load deflections should be limited to 1/800 for structures with only vehicles and 1/1000 for structures which also provide for pedestrians.

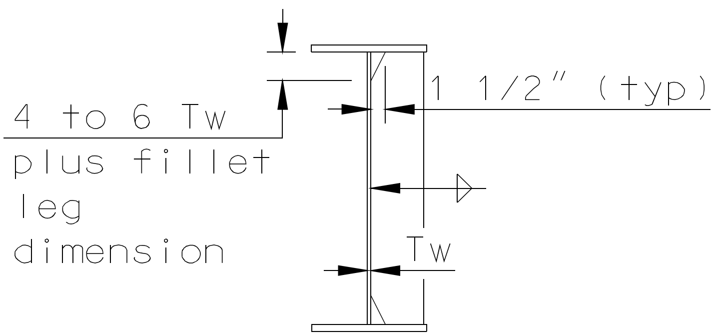
IV-02.06.7 Diaphragms

Interior diaphragms should not be used on prestressed box girders, except when the span is over a roadway or a railroad track and the girders are subject to impact from overheight loads. For prestressed I-beams, no intermediate diaphragms are required for spans of 45 feet or less. Provide one intermediate diaphragm at the midpoint in beams from 45 to 90 feet long. Provide intermediate diaphragms at 1/3 points in spans over 90 feet long. Concrete diaphragms should be placed at least 72 hours before the slab. Prestressed box beam diaphragms may be placed before the slab; however, they should have a 72 hour cure before slab placement commences. Steel diaphragms are not allowed for prestressed beam superstructures.

On steel I-beam bridges, with integral abutments, the abutment backwall should be placed up to the top flange at least 72 hours before the slab. For steel girders 48 inches deep or more, steel X-frame or K-frame diaphragms should be used. For beams less than 48 inches deep, steel channel diaphragms should be used.

IV-02.06.8 Stiffeners, Transverse and Bearing

Single or paired transverse stiffeners may be used. For paired stiffeners, the same details as shown for a single stiffener should be used. When longitudinal stiffeners are required, all transverse stiffeners should be placed on one side of the web, and the longitudinal stiffener placed on the opposite side.



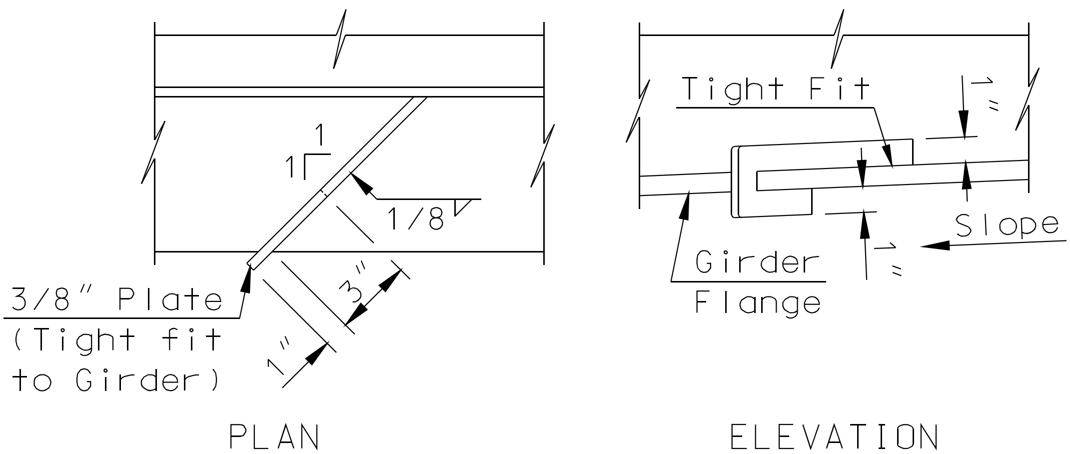
Fillet weld (both sides) to both flanges when used as a cross-frame or diaphragm connection plate. Otherwise, a tight fit to tension flanges and fillet weld to compression flanges should be used. As an option, when the stiffener is not used as a connector plate, the stiffener may be cut short from the tension flange by a distance equal to the vertical leg of the cope. For bearing stiffeners at piers and abutments, fillet weld both sides of the stiffener to the top flange, mill to bear and fillet weld to the bottom flange. The same cope dimensions as used for transverse stiffeners should be used.

IV-02.06.9 Welded Steel Girders

No flange plate should be less than 3/4 inch thick nor less than 12 inches in width. Plate sizes should be as controlled by product availability in the AISC Manual of Steel Construction and availability from suppliers. The use of hybrid girders is not recommended. Optional field splices should be provided on the plans if deemed necessary or practical. Tension members should meet the longitudinal Charpy V-notch test. Top and bottom flanges may be different sizes at the piers.

IV-02.06.9.1 Drip Plate

Drip plates should be used on all weathering steel girder bridges. Drip plates should be placed 5' from the faces of supports to avoid staining the concrete. Drip plates should be placed on the outside of the exterior girders on the up-grade side of all supports. See details below.



IV-02.06.10 Rolled Steel Beams

Typically, no cover plates should be used on rolled beams for new structures.

IV-02.06.11 Shear Connectors

7/8 inch diameter stud shear connectors should be used in positive and negative moment areas, spaced according to AASHTO specifications.

IV-02.06.12 Surface Treatment for Bolted Joints

Bolted joints should be designed for a Class A splice. Faying surfaces should be primed the same as the rest of the beam.

IV-02.06.13 Paint System and Color

All painting on new steel should be done in the shop. The paint system should be inorganic zinc primer and one coat of polyurethane. For maintenance painting, one coat of aluminum epoxy mastic and one coat of polyurethane should be used. Surface preparation should be as stated in the North Dakota Standard Specifications and its supplements. The color should be determined by the District Engineer.

IV-02.06.14 Grades of Structural Steel

Structural steel grades should be as specified by AASHTO specification M270, Grade 36, 50, or 50W.

IV-02.06.15 Bolts

Bolted connections should generally use 7/8 inch diameter bolts, as specified by AASHTO M164.

IV-02.06.16 Cantilever Design

Cantilevered decks should be designed according to AASHTO. Both wheel loads and barrier impact loads should be checked. When the cantilever length exceeds the I-girder depth, or 11/2 times the box girder depth, a precautionary note on possible beam twisting during construction should be added to the plans.

IV-02.06.17 Girder Lines

All structures should have a minimum of three girder lines, but four lines are preferred.

IV-02.06.18 Steel Erection

For shop assembly (reference AASHTO Division II), progressive girder assembly should be specified on the plans except for bridges with complex geometry. For complex structures, full girder or complete structure shop assembly should be specified. Requirements should be determined at the preliminary engineering meeting. Field erection should be as specified in the North Dakota Standard Specifications.

IV-02.06.19 Stay-in-place Forms

Stay-in-place forms should be used only when conventional forming cannot be used.

IV-02.06.20 Class of Concrete and Cement Type

Superstructure concrete should be Class AAE-3 with f_c = 4000 psi. Type I or IA cement should be used.

IV-02.06.21 Concrete Treatment and Surface Finish

Plans should include a bid item for penetrating water repellant on the driving surface of the bridge. Type D surface finish should be used for barrier surfaces that are visible to the motorist. Other surfaces should be finished according to the North Dakota Standard Specifications.

IV-02.06.22 Concrete Cure

Superstructure concrete should be cured using methods specified by the North Dakota Standard Specifications.

IV-02.06.23 Design for Future Wearing Surface

Structures should be designed for a 15 psf future wearing surface.

IV-02.06.24 Cover Over Reinforcement

Concrete cover over reinforcement should be as specified by AASHTO, except that the cover over the top layer of deck reinforcement should be $2^1/_2$ inches. When doing design calculations, assume that ½" of the 2 ½" cover on the top reinforcement is worn off.

IV-02.06.25 Minimum Deck Thickness

Minimum thickness of the deck slab for any structure should be $7^1/_2$ inches.

IV-02.06.26 Minimum Reinforcing Steel

Bridge decks should have minimum reinforcement as specified by AASHTO.

IV-02.06.27 Reinforcing Steel Splices

Reinforcing steel splices should be as specified by AASHTO, except that staggered splice locations are recommended.

IV-02.06.28 Epoxy Coated Reinforcement

All reinforcing steel in superstructures should be epoxy coated reinforcement.

IV-02.06.29 Expansion Joints

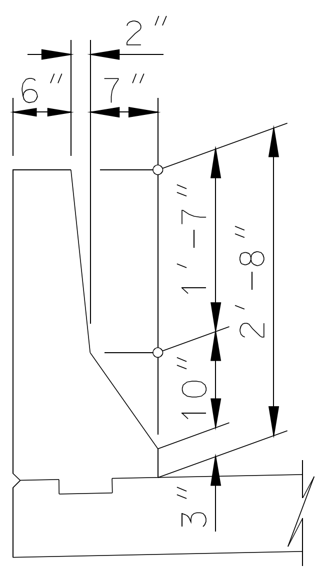
When expansion joints are necessary, strip seals for joints with up to 4 inches of movement should be used, and terminate at the edges of the slab. For joints with greater than 4 inches of movement, finger type joints with troughs should be used. For expansion joints in barrier walls with more than 4 inches of movement, sliding steel plates should be used.

IV-02.06.30 Minimum Deck Concrete Placement

Standard Specifications require a minimum placement rate of 25 cubic yards per hour. If a greater rate of placement is needed, it should be noted on the plans. The rate of placement may be based upon a 10-hour work day. Full width deck pours should be utilized when there is no stage construction (decks 100 feet wide have been placed successfully).

IV-02.06.31 Bridge Railings

Bridge railings should be designed according to AASHTO. For new rail, the 2'-8" barrier should be used (see sketch below). The flared transition as shown in Appendix IV-04B should be used. The two-tube retrofit may be used on existing rail where applicable. Only approved transitions and guardrail attachments should be used. On two-tube retrofit plans, add the note, "The anchor bolts should be embedded into concrete with a chemical adhesive system that can develop a tensile strength of at least 18,250 lbs." Mechanical anchorages should not be allowed.



BARRIER RAIL

IV-02.06.32 Sidewalk Design

Pedestrian facilities should be designed according to AASHTO specifications.

IV-02.06.33 Pedestrian Canopies

When a pedestrian facility goes over a roadway or a railroad, a pedestrian canopy should be considered. Pedestrian canopies are generally not required for walkways over waterways.

IV-02.06.34 Canopies for Construction

Dimensions and specification requirements are not in the North Dakota Standard Specifications and should be shown on the plans.

IV-02.06.35 Deck Overlays

The design of deck overlays should be as specified in the North Dakota Standard Specifications for low slump or latex-modified concrete. Typically, milling machines (mechanical equipment) are used for removal. If the engineer determines that hydrodemolition removal is necessary, 1 ½" minimum deck removal should be specified, and the overlay concrete quantities should be based on a 2 1/4" depth.

IV-02.06.36 Rehabilitation

Rehabilitated structures should be designed for a minimum live load of HS20.

IV-02.06.37 Longitudinal Deck Joints

When widening a deck, the longitudinal joint should be over a girder where possible. In this case the joint should be sawed and sealed with silicone sealant. If the joint is not located over a girder, a keyway should be provided in the joint to transfer the shear.

IV-02.06.38 Joint Spacing in Barriers

Joints in barriers should not be used unless required by an expansion joint in the deck. "V" grooves equally spaced (approximately every 10 feet) between adjacent substructure units should be used.

IV-02.06.39 Deck Drainage

Deck drainage should be designed according to FHWA Hydraulic Circular No. 12, "Drainage of Highway Pavements". Typically, deck drains are 6" diameter PVC pipe through the deck. If the deck geometry is such that the water running through the deck drain would hit the girder, the drain should be galvanized steel tubing (4" x 6" minimum) extending to the bottom of the girder and braced as required.

IV-02.06.40 Roadway Width for Estimating

The out-to-out dimension of the bridge deck, including sidewalks, should be used for estimating purposes.

IV-02.07 Prestressed Concrete

IV-02.07.1 Shapes

Modified “I” sections or box sections are normally used.. Deeper sections are more economical. “I” sections are more economical than box sections. Depth of member generally depends upon clearance requirements. For detailed information, see Appendix IV-04A. End blocks should be used for all beams.

IV-02.07.2 Stress Steel

½" diameter 270 ksi low relaxation strands as specified in AASHTO M203 should be used. See Appendix IV-04A. Special ½" diameter strands and 0.6" diameter strands are allowed at two inch spacing.

IV-02.07.3 Design Compressive Stresses for Concrete

A minimum of 4000 psi at stress transfer should be used. The compressive strength at 28 days should be a minimum of 5000 psi. The design maximum strength should be approximately 6500 psi.

IV-02.07.4 Tension

Allowable tension should be as specified by AASHTO specifications. The computer program allows 424 psi. See Appendix IV-04A.

IV-02.07.5 Concrete Cover Over Reinforcement

A minimum of 1" of concrete cover should be used for stirrups and tie bars. A minimum of 1 1/2" of concrete cover should be used for prestressing steel and main reinforcement.

IV-02.07.6 Reinforcing Steel

Reinforcing steel should be designed according to AASHTO specifications. Grade 60 reinforcement should be used. Grade 40 rebar may be used for the reinforcing that requires bending after beam fabrication.

IV-02.07.7 Continuous Girders

Prestressed beams up to 48" in depth should be designed as continuous, composite, using 90% of the simple moment due to live load. Beams greater in depth should be designed simple, composite, but should be detailed as continuous.

IV-02.07.8 Computer Programs

See the "Prestressed Girder Design and Checking Guide" in Appendix IV-04A.

IV-02.07.9 Losses

AASHTO specifications and Appendix IV-04A should be used.

IV-02.07.10 Plan Information

Shop drawings, showing all details including de-tensioning concrete strength, 28 day concrete strength, and strand locations should be required and so noted on the plans.

IV-02.07.11 Post Tensioned Concrete

Post tensioned concrete is not recommended.

IV-02.07.12 Debonded Strands

Partially and fully debonded strands are allowed.

IV-02.07.13 Risers

A positive riser should be used on I-beams and box girder beams.

IV-02.08 Cast In Place-Reinforced Concrete Box Culverts (CIP-RCB) and Precast RCB

IV-02.08.1 Size Capabilities

The RCB computer program parameters range from a single 4'x4' RCB to a quadruple 16'x16' RCB. Sizes in between are available in 1' increments.

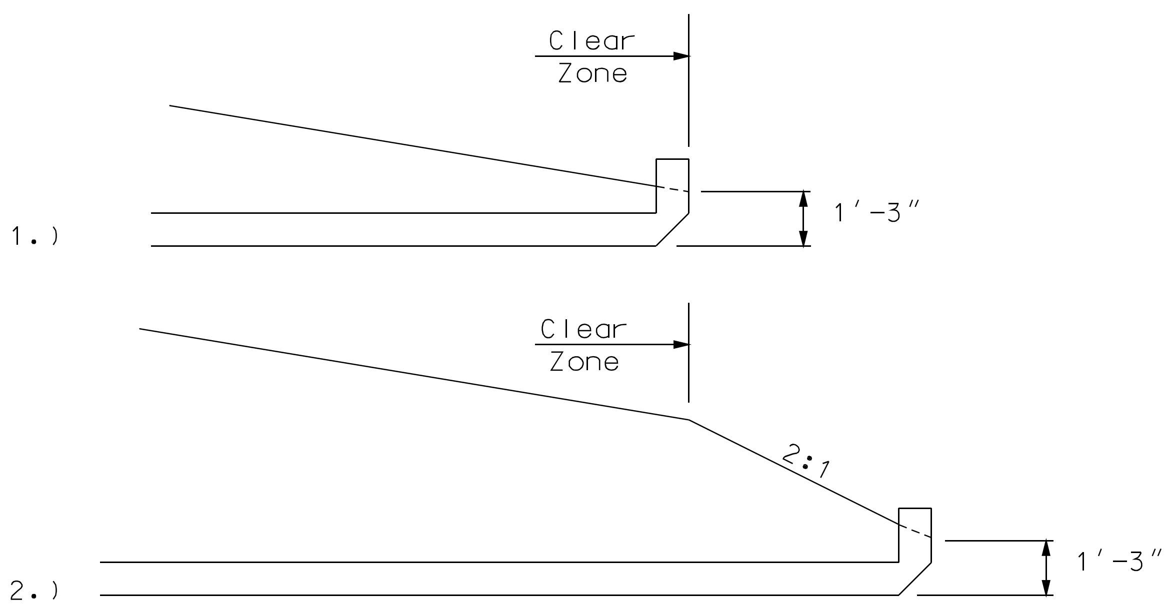
IV-02.08.2 Size and Length

Size of the RCB should be determined by hydraulic requirements. The length of a RCB should be determined by cover and safety zone requirements according to The AASHTO Roadside Design Guide and the following two methods:

Box Culvert Length Determination

Box culvert length will be calculated by one of the following criteria.

1. Low fill: If the embankment cross section intersects a point 1'-3" above the bottom of the roof of the box before the edge of the clear zone then the outside edge of the parapet should extend to the clear zone. The embankment should be warped to intersect the parapet 1'-3" above the bottom of the roof of the box.



2. High fill: The roadway cross-section should be maintained until the edge of the clear zone. At that point the slope of the embankment shall change to 2:1 and continue at that slope until it intersects the parapet 1'-3" above the roof of the box.

IV-02.08.3 Skewed Culverts

For a skew of less than 15E, a square end should be used. Skewed culverts should be designed for skew angles in 5E increments. The RCB plotting program plots right and back. If the skew is opposite, the details should be clarified with a note on the plans. See Appendix IV–04 G1 for details.

IV-02.08.4 Class of Concrete, Type of Cement

RCB concrete should be Class AE-3. Cement should be Type I or IA, unless sulfates are present and other types are recommended by the Materials Division or determined at the TS&L inspection.

IV-02.08.5 Reinforcement

The RCB design program uses Grade 60 reinforcement. It also determines minimum reinforcement and reinforcing steel splices.

IV-02.08.6 Concrete Cover over Reinforcement

Concrete cover over reinforcement should be as specified by AASHTO specifications.

IV-02.08.7 Concrete Finish

If used as an underpass, surface finish "C" should be specified for exposed portions of the RCB. Graffiti protection may be used when requested by the district or political subdivision.

IV-02.08.8 Loadings

Cast-In-Place RCB should normally be designed for HS25 live loading; however, the RCB design program is capable of using any HS live load. For earth loading, 5'-0" fill height increments should be used..

IV-02.08.9 Culvert Extensions

If the amount of fill increases by more than 2 ½ feet, existing RCB's should be checked for allowable live loads before extending. Decisions to extend should be made by the design engineer and the Bridge Engineer. Extensions should be designed by the RCB design program. Remove a portion of the existing box culvert in order to tie the extension to the existing reinforcing steel

IV-02.08.10 Quantities

The determination of quantities for concrete and reinforcing steel is the responsibility of the Bridge Division. Refer to Appendix IV-04G for quantities. The Design Division should be informed of the limits of riprap, if scour protection is proposed.

IV-02.08.11 Hydraulic Data

The hydraulic data for the proposed culvert should be placed on the RCB structural drawings, as required by the FHWA.

IV-02.08.12 Drawing Number/Structure Number

The drawing number/structure number (highway and mile/reference point) should be added to the detail drawings.

IV-02.08.13 Precast RCB

When feasible, precast RCB's should be shown as alternates to CIP RCB's.

IV-02.08.14 Precast RCB-Multibarrel

Multibarrel structures may be cast in one section, or may be single barrel or multibarrel units placed side by side. The space between units should be a maximum of 6" and a minimum of 3". This space should be backfilled with controlled density backfill. Exposed areas of controlled density backfill should be capped with two inches of full strength concrete to provide weather protection for the low density fill. See Appendices IV–04 G1 and G2 for details.

IV-02.08.15 Controlled Density Backfill

The controlled density backfill should be a blend of cement, water, pozzolanic materials, and fillers. The material should be fluid at the time of placement in order to flow into and fill voids in the backfill area. The material should be capable of supporting normal loads after six hours and should have a compressive strength in the range of 75 to 125 psi at 28 days. The contractor should provide mix designs and compression strength test results of the material to the engineer for approval five days prior to placement.

IV-02.09 Miscellaneous

IV-02.09.1 Welding

Field welding, other than welding for piling, is rarely permitted. Welder and welding procedure should be certified through the Materials and Research Division. Large fabricated bearings, or other similar assemblies, require stress relief (use plan note). All structural welding should comply with AASHTO/AWS specifications.

IV-02.09.2 Concrete Admixtures

Proposed concrete admixtures should be approved by the Materials and Research Division. The use of admixtures should be in accordance with the North Dakota Standard Specifications for Road and Bridge Construction, Vol 1.

IV-02-09.3 Retention of Design Records and Plans

The Bridge Division retains design records and a copy of the plans for bridges and culverts in division files.

IV-02.09.4 Shop Drawings

North Dakota Standard Specifications require shop drawings for structural steel. Others should be called for on the plans. Shop drawings for bridge items should be sent to the Construction Services Division by the contractor. Construction Services Division sends them to the Bridge Division for checking. They should be returned to Construction Services, who will be responsible for distribution of the approved shop drawings. Copies of approved shop drawings should be retained by the Bridge Division until construction is completed, and then transferred to the Records Center.

IV-02.09.5 Plan Sheet Authorship

Initials of both the designer and detailer should be placed on each plan sheet.

IV-02.09.6 Approach Slabs

Approach slabs should be used on all highway bridges. The standard length is 20 feet, and should be designed for an HS25 live load. Assume a span length of 10 feet for design purposes. Approach slabs on bridges with Jersey barrier should use the flared transition shown in Appendix IV-04B. Approach slabs on other bridges should have a three inch curb to direct water to the end of the approach slab. Excavation and backfill quantities should be computed and shown as bid items, or may be included in approach slab bid item. For details, see Appendix IV-04C. For concrete pavement, check with the Design Division for dowel or tie bar placement.

IV-02.09.7 Drainage

Water should be allowed to flow off the approach slab at the end of the transition section, 13'-7" from the bridge end. Fiberglass roving, or similar anti-erosion material, should be provided by the Design Division on the roadway foreslope 13'-7" from the bridge end. Whenever possible, existing drains should be removed and the pipe plugged. This means that a 20 foot approach slab should be satisfactory for all installations except where existing drains cannot be eliminated by the Design Division. Approach slabs without the crash tested transition should be modified to provide a similar drainage pattern.

IV-02.09.8 Super Span, Con-Span Culverts, Etc.

This type of structure may be considered on a limited basis.

IV-02.09.9 Design Temperature Range

To determine the design temperature range for structures, AASHTO guidelines for cold climate should be used. For concrete structures, a mean temperature of 40EF should be used.

IV-02.09.10 SPP and SPPA Cutoff Walls

Headwalls and cutoff walls should normally used on all structural plate steel pipe.

IV-02.09.11 Retaining Walls

Retaining walls should be designed according to AASHTO specifications. Design of reinforced earth retaining walls, and similar structures, should be done by the Materials and Research Division. Patented walls may be considered for special installations.

IV-02.09.12 Low Modulus Silicone Sealant

Silicone sealant (type 5) should be used to fill joints as designated on the plans.

IV-02.09.13 Materials Prequalification

Prequalification of products should be done by the Materials and Research Division.

IV-02.09.14 Cold Joints

Cold joints in bridge decks should normally be saw cut and sealed with silicone sealant (type 5).

IV-02.09.15 Water Repellent and Silicone Sealant (type 5)

Whenever a silicone type joint sealer is specified for construction joints in decks which are to be treated with a penetrating water repellent, the following construction sequence should be specified by plan note:

1. The joint(s) should be grooved with a saw.

2. The water repellent should be applied to the entire deck, including the grooved joint(s).

3. The water repellent should be allowed to cure in accordance with the manufacturer's recommendations.

4. The joint sealer should be placed in the grooved joint(s) and allowed to cure.

IV-02.09.16 Plan Notes, Special Provisions, Supplemental Specifications

The majority of the plan notes are standard for all projects and are stored in the word processor. If a special provision is needed , it should be requested from Maintenance and Engineering Services in accordance with the instructions in Section III-20 of this manual. For coordination of plan notes, special provisions, standard specifications, and supplemental specifications, see Sec 105.05 of the North Dakota Standard Specifications for Road and Bridge Construction.

IV-02.09.17 Jersey Barrier Retrofit

Jersey barrier retrofits should be designed to satisfy AASHTO specifications.

IV-02.09.18 Concrete Deck Removal

Deck concrete should not be allowed to fall into streams nor be used as riprap. Concrete should be disposed of as directed by the engineer.

IV-02.09.19 Rebar Designations

A standard rebar designation system should be used for all bridge plans.

IV-02.09.20 Deck Replacement

Replacements for decks that must be totally removed because of condition should be designed for a minimum of HS20 live load.

IV-02.09.21 Slope Protection

The need for slope protection should be established at the pre-engineering meeting. The type of slope protection to be used should also be determined at this meeting. When used on skewed structures, the edges of the slope protection should be parallel to the roadway.

IV-02.09.22 Preliminary Engineering Procedures

A preliminary engineering meeting should be held prior to the final design of each bridge project. Persons in attendance should include the Bridge Engineer, section leader, the designer of the project, and others as appropriate.

IV-02.09.23 Final Plan Disposition (for plans prepared within the DOT)

The originals of the final bridge plans should be submitted to the Design Division according to the date specified in the Milestone system. The plans should be accompanied by a letter of transmittal signed by the Bridge Engineer or the design section head. A copy of the plans should be kept by the designer. A complete copy of the printed structural project plans should be filed by the structural management section.